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(71) Applicant: HITACHI METALS, LTD.
Minato-ku, Tokyo (JP)

(72) Inventors:
- Tai, Hiroyuki
Iwami-gun, Tottori-ken (JP)
- Taketa, Tsuyoshi
Iwami-gun, Tottori-ken (JP)
- Tanaka, Toshihiko
Tottori-shi, Tottori-ken (JP)

(74) Representative: Strehl Schübel-Hopf & Partner
Maximilianstrasse 54
80538 München (DE)

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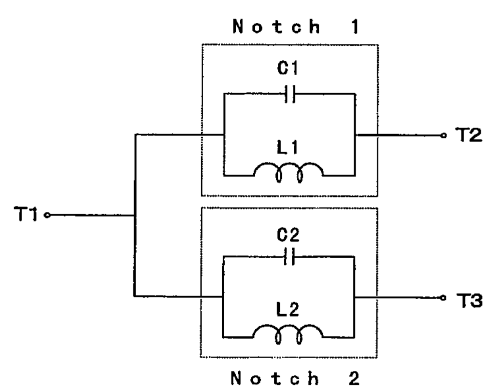
(54) Frequency separator for use in dual-band mobile phone terminals

(57) A frequency separator used for a dual-band mobile phone terminal using two bands of f1 and f2 has a first notch circuit comprising a capacitor component (C1) and an inductance component (L1) passing a signal of the band f1 and a second notch circuit comprising a capacitor component (C2) and an inductance component (L2) passing a signal of the band f2. The first notch circuit is interposed between an antenna (T1) of the dual-band mobile phone and a communication circuit (T2) handling the signal of the band f1, the second notch circuit is interposed between an antenna (T1) of the dual-band mobile phone and a communication circuit (T3) handling the signal of the band f2. An end portion is formed by interconnecting the first notch and notch circuits is connected to the antenna side of the dual-band mobile phone for subjecting the signal input to branching to each of the communication circuit sides handling the respective signals of bands f1 and f2, thereby making it possible to select one band of the two bands of f1 and f2 and talk over the dual-band mobile phone.

Fig. 1



EP 1 291 956 A1

Description

BACKGROUND OF THE INVENTION

[0001] The present invention relates to a frequency separator used for a dual-band mobile phone terminal, specifically relates to a frequency separator for use in branching bands for a dual-band mobile phone.

[0002] Fig. 10 is a schematic diagram showing a circuit of a conventional frequency separator which comprises a low-pass filter and a high-pass filter. Figs. 11 and 12 are block diagram showing other conventional frequency separators disclosed in Japanese Patent Laid-Open No. 3-216002. The frequency separator of Fig. 11 corresponds to that of Fig. 10 which has an additional low-pass filter connected to the high-pass filter. The frequency separator of Fig. 12 corresponds to that of Fig. 11 in which a rejection filter is added to each of the low-pass filter and the high-pass filter.

[0003] Generally, these frequency separators have a dielectric coaxial resonator which comprises a dielectric ceramic cylinder having electrodes formed on both the inner and outer surface of the cylinder. Due to this structure, it has been difficult to reduce the size of the frequency separator.

[0004] The recent spread of the mobile phone is striking, and many efforts are directed to improve the performance of portable terminal equipment. For example, a dual-band mobile phone, which enables a speech in two different frequency bands, has been proposed. The dual-band mobile phone must have a device for selecting one from the two frequency bands, i.e., a frequency separator. Also, such a frequency separator must be small in size to be mounted in a portable terminal equipment.

[0005] Fig. 13 is a graph showing insertion loss of a frequency separator, having a conventional branching circuit shown in Fig. 10, for use in a dual-band telephone using two bands of f1=824 to 894 MHz and f2=1850 to 1990 MHz. As seen from Fig. 13, the attenuation is as small as 5 to 10 dB in both bands. Thus, the conventional frequency separator has been insufficient in branching one signal of band f1 and the other signal of band f2.

[0006] By the constructions shown in Figs. 11 and 12, the insertion loss can be decreased with respect to each of the f1 and f2 bands. However, these constructions are rather complicated, and therefore, frequency separators having such constructions are inevitably large in size. Since the frequency separator to be mounted in a mobile phone is required to be as small in size as possible and be of high performance, the conventional frequency separator of large size is apparently not suitable for a mobile phone.

[0007] Japanese Patent Laid-Open No. 6-88506 discloses a duplexer comprising both dielectric layers forming capacitor electrode and coil electrodes, and a low-pass filter part on their surfaces and dielectric layers forming coil electrodes and capacitor electrodes, and a high-pass filter part on their surfaces. However, since in its high-pass filter part, a coil is interposed in parallel between a notch circuit consisting of a capacitor and a coil and a common output terminal, the attenuation characteristic curve is so sharp that it is impossible to attain the sufficient attenuation degree through a broad band of 70 MHz at a signal band (f1) of 824 to 894 MHz of GSM (Global System for Mobile Communications).

[0008] EP 0 641 035 A2 discloses a shared device for an antenna duplexer and a dielectric filter for forming the duplexer of the SIR (Stepped Impedance Resonator, but does not describe the separation of the transmit-receive signals in different systems (GSM and DCS) used for dual-band mobile phone.

OBJECT AND SUMMARY OF THE INVENTION

[0009] Accordingly, an object of the present invention is to provide a high performance frequency separator used for a dual-band mobile phone having a novel construction and being small in size.

[0010] As a result of the intense research in view of the above objects, the inventors have found that good branching characteristics can be attained by making the frequency separator with simple circuits into a multilayered structure, and further found that the size of the frequency separator can be reduced by the multilayered structure.

[0011] Thus, in a first aspect of the present invention, there is provided a frequency separator used for a dual-band mobile phone using two bands of f1 and f2 having a first notch circuit comprising a capacitor component and an inductance component passing a signal of the band f1 and a second notch circuit comprising a capacitor component and an inductance component passing a signal of the band f2,

the first notch circuit being interposed between an antenna of the dual-band mobile phone and a communication circuit handling the signal of the band f1, the second notch circuit being interposed between an antenna of the dual-band mobile phone and a communication circuit handling the signal of the band f2, and

an end portion formed by interconnecting the first notch circuit and the second notch circuit being connected to the antenna side of the dual-band mobile phone for subjecting the signal input to branching to each of the communication circuit sides handling the respective signals of bands f1 and f2, thereby making it possible to select one band of the two bands of f1 and f2 and talk over the dual-band mobile phone. The capacitor component comprises at least one capacitor, and also, the inductance component comprises at least one inductor.

[0012] In the present invention, the first and second notch circuits each composed of a capacitor component and an inductance are constituted by pattern electrodes formed on interfaces of each of a plurality of insulating layers formed by integrally laminating a dielectric ce-

ramic material having a dielectric constant of 5-15, which can be sintered at a temperature of 950°C or lower.

[0013] The pattern electrodes constituting the capacitor and the inductance of the present invention are formed on an interface of each different insulating layer of the plurality of insulating layers.

[0014] In the present invention, the pattern electrodes constituting the inductance are formed by a line electrode branched to two directions on the surface of each insulating layer.

[0015] Specifically, in the present invention, the attenuation in a signal of the band f1 in the first notch circuit is 15 dB or larger and the attenuation in a signal of the band f2 in the second notch circuit is 15 dB or larger, and one practical embodiment of the present invention is a dual-band mobile phone terminal made use of the frequency separator according to the present invention mentioned above.

BRIEF DESCRIPTION OF THE DRAWINGS

[0016]

Fig. 1 is a schematic diagram showing an equivalent circuit A of a frequency separator used for a dual-band mobile phone of the present invention;

Fig. 2 is a schematic diagram showing an equivalent circuit B of another frequency separator used for a dual-band mobile phone of the present invention;

Fig. 3 is a schematic diagram showing an equivalent circuit C of still another frequency separator used for a dual-band mobile phone of the present invention;

Fig. 4 is a schematic illustration showing each insulating layer constructing a frequency separator used for a dual-band mobile phone having the circuit of Fig. 1;

Fig. 5 is a cross-eye view of the frequency separator used for a dual-band mobile phone of Fig. 4;

Fig. 6 is a graph showing insertion loss characteristics of a frequency separator used for a dual-band mobile phone having the circuit of Fig. 1;

Fig. 7 is a schematic illustration showing each insulating layer constructing a frequency separator used for a dual-band mobile phone having the circuit of Fig. 3;

Fig. 8 is a cross-eye view of the frequency separator used for a dual-band mobile phone of Fig. 7;

Fig. 9 is a graph showing insertion loss characteristics of a frequency separator used for a dual-band mobile phone having the circuit of Fig. 3;

Fig. 10 is a schematic diagram showing an equivalent circuit of a conventional frequency separator;

Fig. 11 is a schematic illustration showing a block diagram of another conventional frequency separator;

Fig. 12 is a schematic illustration showing a block diagram of still another conventional frequency separator; and

Fig. 13 is a graph showing insertion loss characteristics of the conventional frequency separator having the circuit of Fig. 10.

DETAILED DESCRIPTION OF THE INVENTION

[0017] By referring to the attached drawings, the present invention will be described below in more detail.

[0018] The equivalent circuit A of a first preferred embodiment according to the present invention is shown in Fig. 1. The first embodiment of the frequency separator used for a dual-band mobile phone have a first circuit 1 comprising an inductance component L1 and a capacitor component C1 connected in parallel, and a second notch circuit 2 comprising an inductance component L2 and a capacitor component C2 connected in parallel. One terminal of the first notch circuit 1 is connected to one terminal of the second notch circuit 2 in parallel with respect to a terminal (T1) to construct a frequency separator circuit. If a signal of the band (f1) is intended to pass from the terminal (T1) to the terminal (T2), the insertion loss in the notch circuit 2 is so regulated as to be the largest against the frequency of the band (f1) to gain no output signal from the terminal (T3). On the other hand, if a signal of the band (f2) is intended to pass from the terminal (T1) to the terminal (T3), the insertion loss in the notch circuit 1 is so regulated as to be the largest against the frequency of the band (f2) to gain no output signal from the terminal (T2). In this manner, the signal input to the terminal (T1) is branched.

[0019] The equivalent circuit B of a second preferred embodiment according to the present invention is shown in Fig. 2. The second embodiment of the frequency separator used for a dual-band mobile phone have a first notch circuit 1 comprising an inductance component L 1 and a capacitor component C1 interconnected in series, and a second notch circuit 2 comprising an inductance component L2 and a capacitor component C2 interconnected in series. One terminal of the first notch circuit 1 is connected to one terminal of the second notch circuit 2 in parallel with respect to a terminal (T1) to construct a frequency separator circuit. If a signal of the band (f1) is intended to pass from the terminal (T1) to the terminal (T2), the insertion loss in the notch circuit 2 is so regulated as to be the largest against the frequency of the band (f1) to gain no output signal from the terminal (T3). On the other hand, if a signal of the band (f2) is intended to pass from the terminal (T1) to the terminal (T3), the insertion loss in the notch circuit 1 is so regulated as to be the largest against the frequency of the band (f2) to gain no output signal from the terminal (T2). In this manner, the signal input to the terminal (T1) is branched.

[0020] The equivalent circuit C of a third preferred embodiment according to the present invention is shown in

Fig. 3. The third embodiment of the frequency separator used for a dual-band mobile phone (hereafter, the frequency separator) have, as a main circuit, a first notch circuit 1 comprising an inductance component L1 and a capacitor component C1 interconnected in parallel, and a second notch circuit 2 comprising an inductance component L2 and a capacitor component C2 also interconnected in parallel. The main circuit of Fig. 3 is the same as the equivalent circuit of Fig. 1. One terminal of the first notch circuit 1 is connected to one terminal of the second notch circuit 2 in parallel with respect to the first external terminal ⑦. The other terminal of each of the first notch circuit 1 and the second notch circuit 2 is referred to as a second terminal ④, and a third terminal ⑤, respectively. A capacitor component C3 is connected between the second terminal④ and the earth to construct a low pass filter circuit. A capacitor component C4 is connected to the third terminal ⑤ in series, and an inductance component L3 is connected between the third terminal ⑤ and the earth, thereby constructing a high pass filter circuit. In this frequency separator circuit, the first terminal ⑦, the other terminal ④ of the low pass filter, and the terminal ① of the high pass filter serve as input-output terminals.

[0021] If a signal of the band (f1) is intended to pass from the terminal ⑦ to the terminal ④, the insertion loss in the second notch circuit 2 is so regulated as to be the largest against the frequency of the band (f1) to gain no output signal from the terminal ①. On the other hand, if a signal of the band (f2) is intended to pass from the terminal ⑦ to the terminal ①, the insertion loss in the first notch circuit 1 is so regulated as to be the largest against the frequency of the band (f2) to gain no output signal from the terminal ④.

[0022] Basically, the frequency separator of the present invention comprises 4 to 13 insulating layers. As the material for each insulating layer, a dielectric ceramic material which can be sintered at about 950°C or lower is preferably used. The dielectric constant of the dielectric material is preferably 5 to 15. The dimension and the geometrical shape of each insulating layer and the frequency separator are not strictly limited as far as the object of the present invention is accomplished. Usually, the insulating layer is a rectangular sheet having a thickness of 0.05 to 0.70 mm, a length of 2.0 to 4.5 mm and a width of 1.2 to 3.2 mm. The height of the frequency separator is preferably 1.0 to 1.7 mm. On the surface of each insulating layer, pattern electrodes for the capacitor component or the inductance component is formed, for example, by screen-printing a silver paste.

[0023] Each of the insulating layer (ceramic green sheet) is laminated by a known method to construct a multilayer structure having a plurality of the insulating layers. The multilayer structure is then sintered at 950°C or lower, preferably 850°C to 950°C for 1 to 5 hours in an atmosphere such as air, N_2, N_2 + H_2, etc. to obtain an integral laminate. Then, terminal electrodes are formed on the side surface of the integral laminate to produce the frequency separator of the present invention.

[0024] Fig. 4 is a schematic illustration showing each insulating layer of a chip frequency separator used for a dual-band mobile phone of the first preferred embodiment, and a cross-eye view thereof is shown in Fig. 5. The frequency separator shown in Figs. 4 and 5 has the equivalent circuit A of Fig. 1 and a dimension of 4.5 mm x 3.2 mm x 1.7 mm (height).

[0025] Referring to Fig. 4, an insulating layer (ceramic green sheet having a dielectric constant of 8) 11 having no pattern electrode on the surface thereof constitutes the lowermost layer of the frequency separator. On the insulating layer 11, an insulating layer 12 having pattern electrodes 21 and 22 for the capacitor component. Lead electrodes 21 a and 22a extending from each of the pattern electrodes 21 and 22 are exposed on an edge surface of the insulating layer 12. On an insulating layer 13 to be laminated on the insulating layer 12, a pattern electrode 23 for the capacitor component is formed. A lead electrode 23a extending from the pattern electrode 23 is exposed on an edge surface of the insulating layer 13. On an insulating layer 14 to be laminated on the insulating layer 13, pattern electrodes for the inductance component are formed. A line electrode extending from a lead electrode 31a on an edge surface branches to line electrodes 31b and 31c for the inductance component. The end of the line electrode 31b is made into a through-hole round electrode 42, and the line electrode 31c extends to the opposite edge surface to form a lead electrode 31 d thereon. On an insulating layer 15 to be laminated on the insulating layer 14, a line electrode 31e is formed. One end of the line electrode 31 e extends to an edge surface of the insulating layer 15 and forms a lead electrode 31f. The other end of the line electrode 31e is made into a through-hole electrode 41. The uppermost insulating layer 16 having no pattern electrode is laminated on the insulating layer 15. The multilayer structure thus obtained is sintered, for example, at 900°C to give an integral laminate.

[0026] As shown in Fig. 5, terminal electrodes 51, 61 and 62 are formed on the side surfaces of the laminate. The line electrodes 31e and 31b are interconnected through the through-hole electrode 41 and the through-hole round electrode 42, and constitute an inductance component. The line electrodes 31a and 23a are exposed on the same side surface of the multilayer structure, and interconnected by the terminal electrode 51. The lead electrodes 31f and 21a, which are exposed on the same side surface of the multilayer structure, are interconnected by the terminal electrode 62. Further, the lead electrodes 31d and 22a on the same side surface of the multilayer structure are interconnected by the terminal electrode 61.

[0027] Comparing Fig. 1 with Fig. 4, C1 is constituted by the pattern electrodes 22 and 23, L1 by the line electrode 31c, C2 by the pattern electrodes 21 and 23, and L2 by the line electrodes 31b and 31e.

[0028] The first embodiment had the capacitance and the inductance of C1 = 1.6 pF, L1 = 4 nH, C2 = 3.2 pF, and L2 = 10 nH, and was confirmed to be suitable for a frequency separator of a dual-band mobile phone using a frequency band (f1) of 824 to 894 MHz and a frequency band (f2) of 1850 to 1990 MHz.

[0029] Fig. 6 is a graph showing insertion loss characteristics of the first embodiment of a frequency separator used for a dual-band mobile phone in which f1 and f2 were set to 860 MHz and 1920 MHz, respectively. As seen from Fig. 6, the attenuation is far larger than 15 dB, and little amount of one band signal runs around to the other band, and therefore, the frequency separator of the present invention has excellent performance in branching the bands.

[0030] Fig. 7 is a schematic illustration showing each insulating layer of a chip frequency separator used for a dual-band mobile phone of the second preferred embodiment, and a cross-eye view thereof is shown in Fig. 8. The frequency separator shown in Figs. 7 and 8 has the equivalent circuit C of Fig. 3 and a dimension of 4.5 mm x 3.2 mm x 1.7 mm (height).

[0031] On an insulating layer 111 constituting the lowermost layer, a pattern electrode 121 for the capacitor component is formed. A part of the pattern electrode 121 extends to be connected to each of external terminals ②, ③ and ⑧. On the insulating layer 111, an insulating layer 112 having a pattern electrode 122 for the capacitor component is laminated. A part of the pattern electrode 122 extends to be connected to an external terminal ④. An insulating layer 113 having thereon a pattern electrode 123 for the capacitor component is laminated on the insulating layer 112. A part of the electrode 123 extends to be connected to each of external terminals ① and ⑥. On the insulating layer 113, is laminated an insulating layer 114 having pattern electrodes 124 and 125 for the capacitor component, each pattern electrode extending to be connected external terminals ④ and ⑤, respectively. An insulating layer 115 having thereon a pattern electrode 126 for the capacitor component is laminated on the insulating layer 114. The pattern electrode partially extends to be connected to an external terminal ⑦. On an insulating layer 116 to be laminated on the insulating layer 115, a pattern electrode 131 for the inductance component is formed in the form of meander line. The pattern electrode 131 is connected to external terminals ④ and ⑤ at both the ends thereof, and to an external terminal ⑦ at an intermediate portion. On the insulating layer 116, an insulating layer 117 having thereon a pattern electrode 132 for the inductance component is laminated. The pattern electrode 132 is in the form of meander line, and connected to external terminals ② and ⑤ at both the ends thereof. An insulating layer 118 having no pattern electrode is laminated on the insulating layer 117 to constitute the uppermost layer. The multilayer structure thus obtained is sintered, for example, at 900°C to give an integral laminate.

[0032] As seen from Fig. 8, terminal electrodes for the external terminals ① to ⑧ are formed on the side surfaces of the laminate.

[0033] Comparing Fig. 3 with Fig. 7, L1 and L2 are constituted by the pattern electrode 131, C1 by the pattern electrodes 124 and 126, and C2 by the pattern electrodes 125 and 126, thereby constructing two notch circuits. Further, the pattern electrodes 122 and 121 constitute C3 of the low pass filter. The pattern electrodes 123 and 125 constitute C4 and the pattern electrode 132 constitutes L3 of the high pass filter.

[0034] In this second embodiment, the capacitance and the inductance were selected as follows: C1 = 1.6 pF, L1 = 4 nH, C2 = 3.2 pF, L2 = 10 nH, C3 = 1.3 pF, C4 = 2.8 pF, and L3 = 4 nH. It was confirmed that the frequency separator of the second embodiment was suitable for a frequency separator of a dual-band mobile phone using a frequency band (f1) of 824 to 894 MHz and a frequency band (f2) of 1850 to 1990 MHz.

[0035] Fig. 9 is a graph showing insertion loss characteristics of the second embodiment of the frequency separator in which f1 and f2 were set to 860 MHz and 1920 MHz, respectively. As seen from Fig. 9, the attenuation is far larger than 20 dB, and little amount of one band signal runs around to the other band, and therefore, the frequency separator used for a dual-band mobile phone the present invention has excellent performance in branching the bands. In the present invention, the attenuation of 20 dB or larger, preferably 20 to 35 dB can be attained.

[0036] In the second embodiment, the pattern electrode 123 constituting C4 of the high pass filter is connected to the external terminals ① and ⑥ at both the ends thereof. As seen from the equivalent circuit C of Fig. 3, the pattern electrode 123 is needed to be connected to only the external terminal ①. The terminal electrodes are formed on each of the external terminals ① to ⑧ by printing a silver paste, baking and plating such as electroplating. When an external terminal to be plated is isolated (dummy terminal), the deposit thickness, in particular in electroplating, is reduced as compared with the deposit thickness of other external terminals connected to anywhere. To eliminate this problem, the external terminal ⑥ was connected to the pattern electrode 123, because such a connection had no influence in the characteristics of the circuit.

[0037] While the invention has been particularly shown and described with reference to the preferred embodiments thereof, it will be understood by those skilled in the art that various other changes in the form and details may be made.

[0038] For example, the pattern electrode for the inductance component may be made in the form other than meander line, for example, spiral line, and the inductance component may be constituted by pattern electrodes on a plurality of insulating layers interconnected by one or more through-hole electrodes. Also, the capacitor component may be constituted by pattern

electrodes on three or more insulating layers being opposite to each other in place of pattern electrodes on two insulating layers as describe above.

[0039] Although, the low pass filter and the high pass filter were used in the second preferred embodiment, either one of the two may be used alone. The frequency separator circuit is mainly constituted by the combination of the notch circuits, and low or high pass filter is used to further improving the branching characteristics. In some cases, the use of only one of two is sufficient for the purpose. For example, when the insulating layers 111 and 112 of Fig. 7 are omitted, the resulting frequency separator includes only the high pass filter. When the insulating layers 113 and 117 are removed, the resulting frequency separator has only the low pass filter.

[0040] As described above, according to the present invention, a frequency separator used for a dual-band mobile phone terminal with a high performance can be obtained from using a rather simple circuits. Also, the simple circuits and the multilayer structure can reduce the size of the frequency separator, and therefore, the frequency separator used for a dual-band mobile phone terminal of the present invention can be suitably applied to a small-sized microwave equipment, in particular, to a dual-band mobile phone.

Claims

1. A frequency separator used for a dual-band mobile phone using two bands of f1 and f2 having a first notch circuit comprising a capacitor component (C1) and an inductance component (L1) passing a signal of the band f1 and a second notch circuit comprising a capacitor component (C2) and an inductance component (L2) passing a signal of the band f2,

   said first notch circuit being interposed between an antenna (T1) of said dual-band mobile phone and a communication circuit (T2) handling said signal of the band f1,

   said second notch circuit being interposed between an antenna (T1) of said dual-band mobile phone and a communication circuit (T3) handling said signal of the band f2, and

   an end portion formed by interconnecting said first and second notch circuits being connected to said antenna side (T1) of said dual-band mobile phone for subjecting the signal input to branching to each of said communication circuit sides handling said respective signals of bands f1 and f2, thereby making it possible to select one band of said two bands of f1 and f2 and talk over said dual-band mobile phone.

2. The separator of claim 1, wherein said first and second notch circuits are constituted by pattern electrodes (21~23, 31) formed on interfaces of each of a plurality of insulating layers (11~16) formed by integrally laminating a dielectric ceramic material having a dielectric constant of 5 to 15, which can be sintered at a temperature of 950 °C or lower.

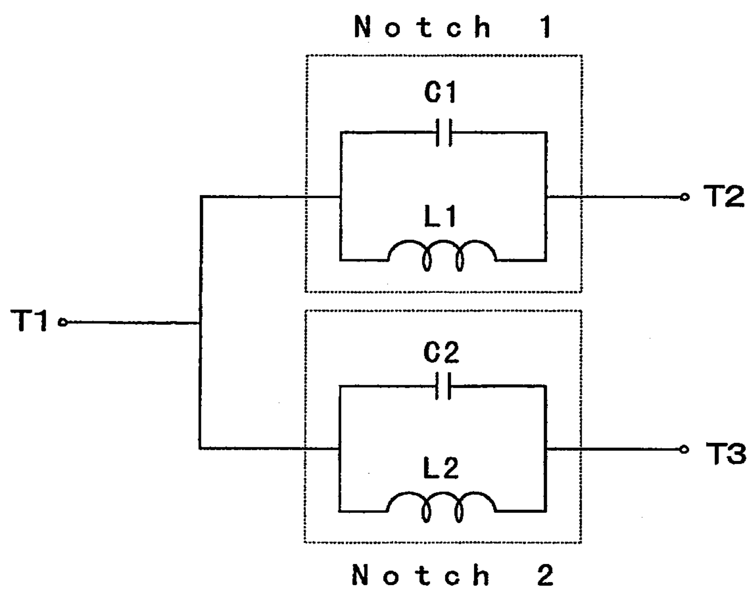
3. The separator of claim 2, wherein said pattern electrodes (21~23, 31) constituting said capacitor and said inductance are formed on an interface of each different insulating layer of said plurality of insulating layers (11~16).

4. The separator of claim 2 or 3, wherein said pattern electrodes (21~23, 31) constituting said inductance are formed by a line electrode branched to two directions on the surface of each insulating layer (11~16).

5. The separator of any preceding claim, wherein the attenuation in said band signal f2 in said first notch circuit is 15 dB or larger and the attenuation in said band signal f1 in said second notch circuit is 15 dB or larger.

6. A dual-band mobile phone terminal using the frequency separator of any preceding claim.

Fig. 1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C2
L2
T3
Notch 2

Fig. 2

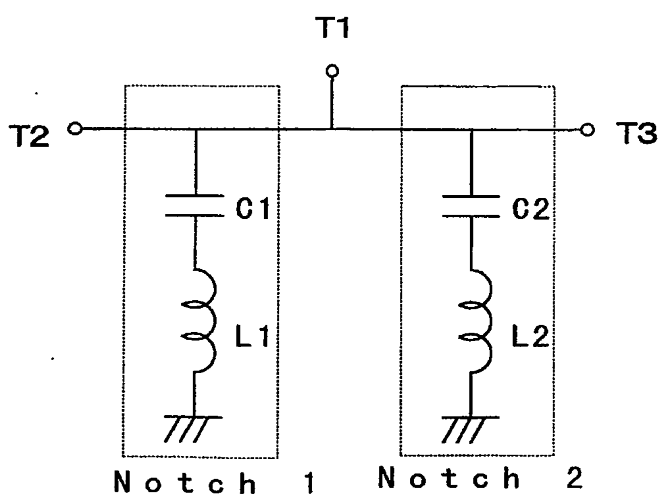
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Fig. 3

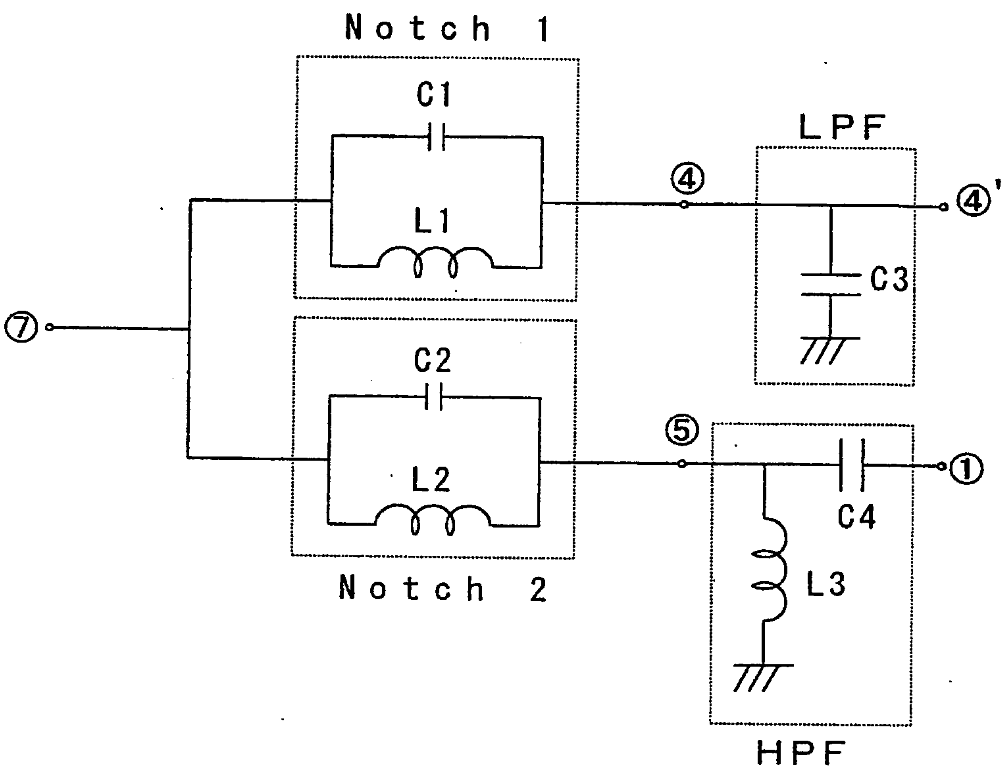

Fig. 4

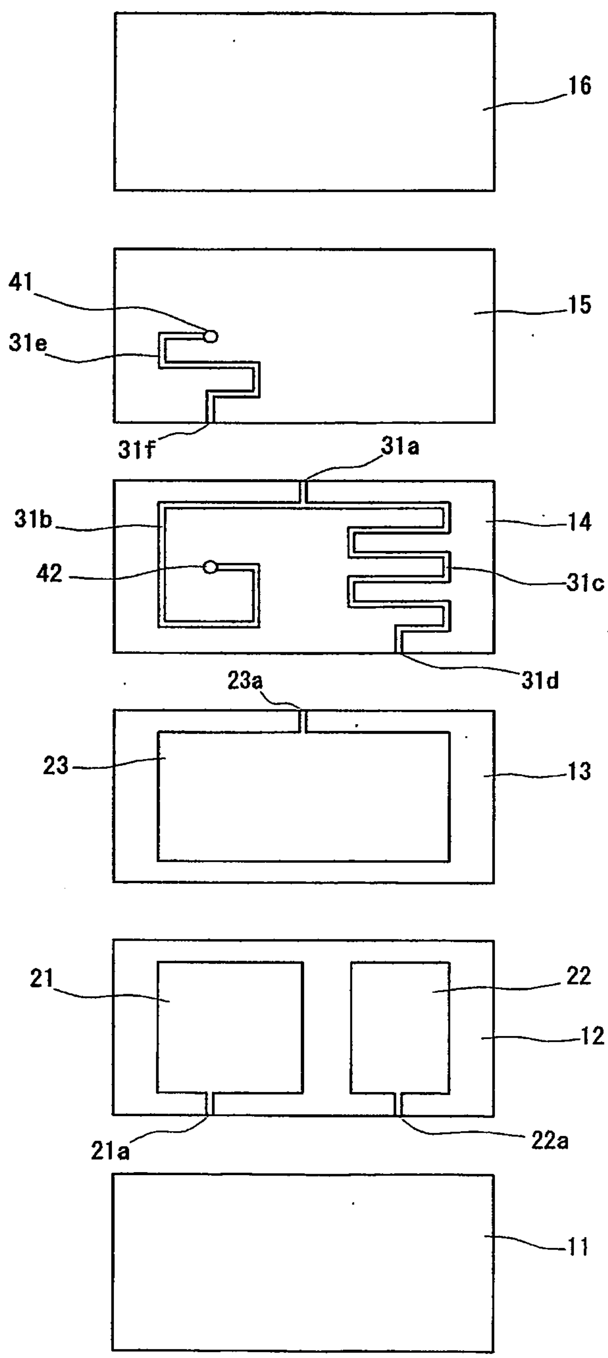

Fig. 5

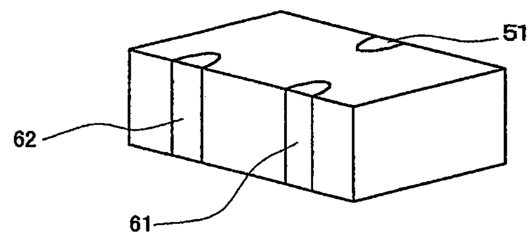

Fig. 10 Prior Art.

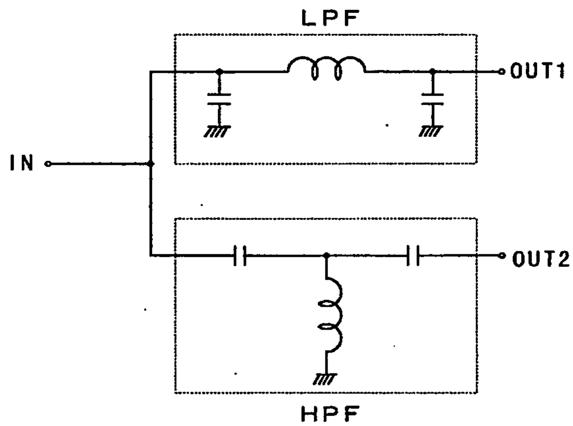

Fig. 11 Prior Art.

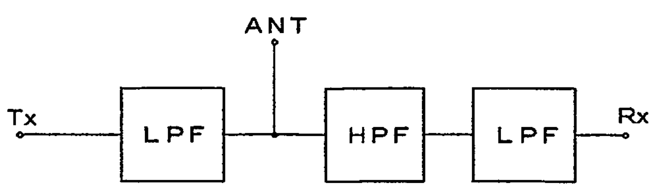

Fig. 12 Prior Art.

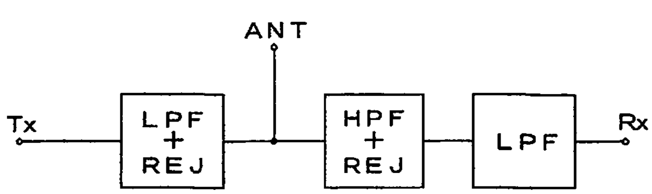

Fig. 6

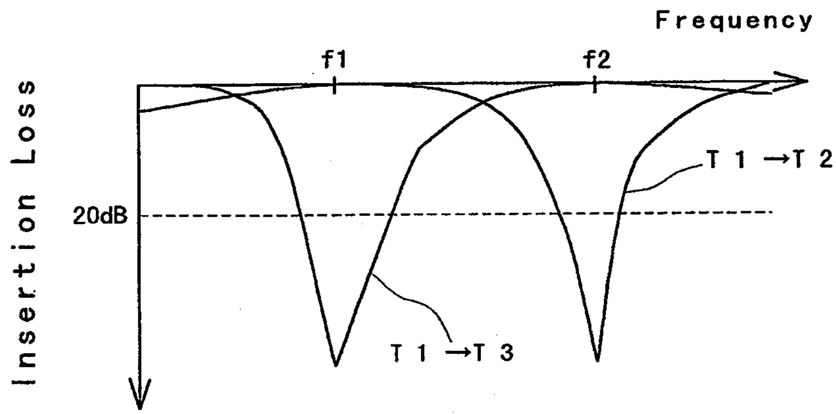

Fig. 13 Prior Art.

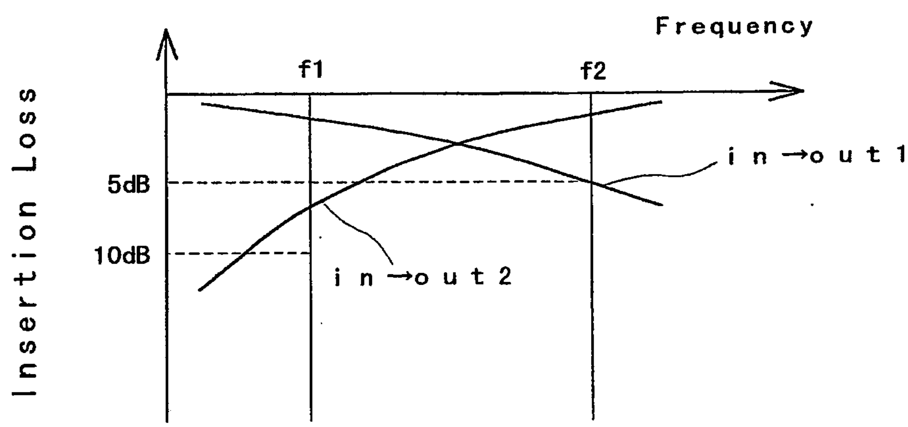

Fig. 7

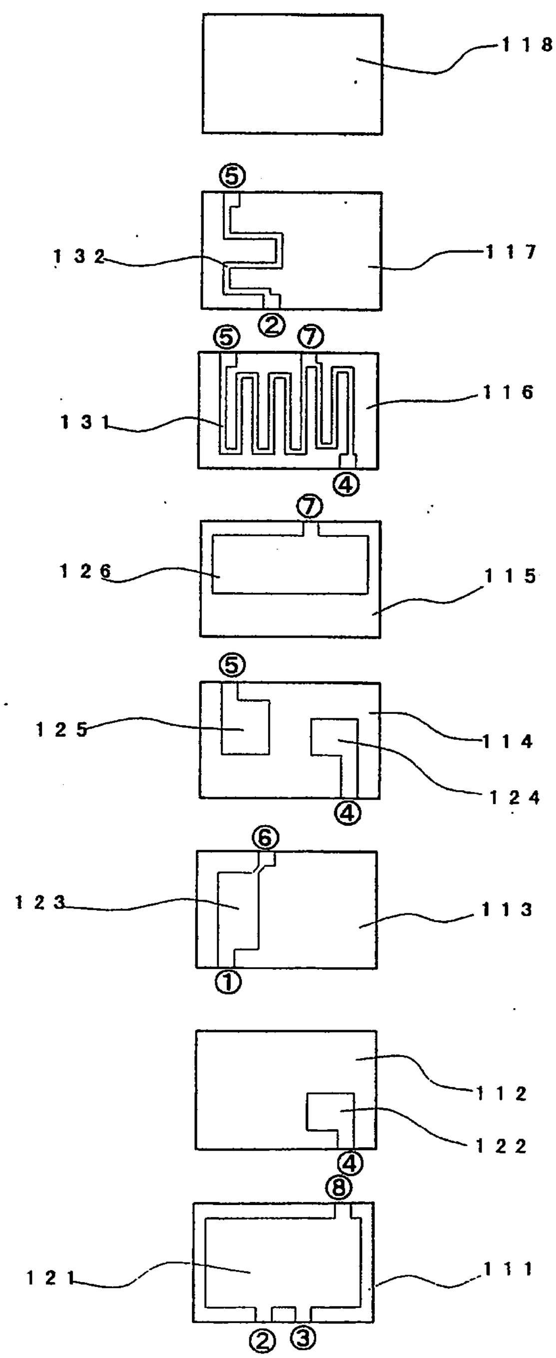

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Fig. 8

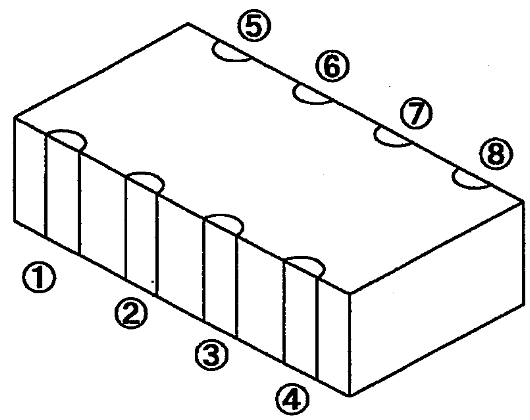
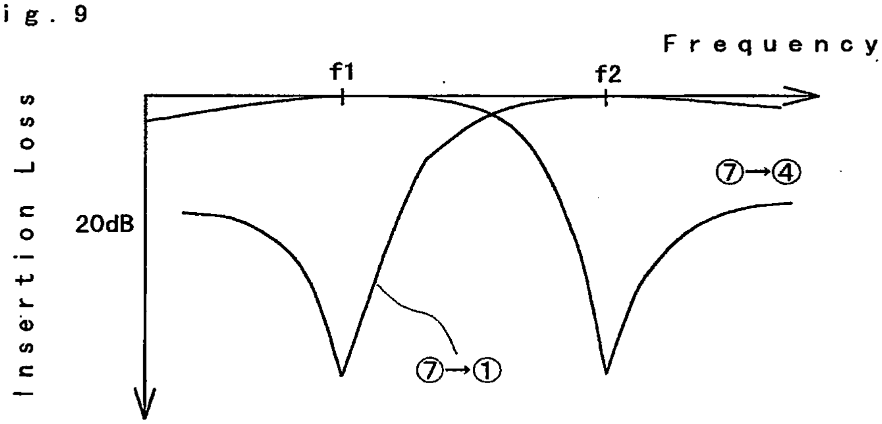


Fig. 9



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EUROPEAN SEARCH REPORT

Application Number
EP 02 02 2889

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
A	EP 0 641 035 A (MATSUSHITA ELECTRIC IND. CO. LTD.) 1 March 1995 (1995-03-01) * page 3, line 1 - line 2 * * column 31, line 27 - line 48 * * column 32, line 30 - column 33, line 15; figures 40,44 * ---	1,3,6	H01P1/213
A	PATENT ABSTRACTS OF JAPAN vol. 18, no. 340 (E-1569), 27 June 1994 (1994-06-27) & JP 06 085506 A (MURATA MFG CO LTD), 25 March 1994 (1994-03-25) * abstract * ---	1	
A	US 3 015 099 A (WILLARD) 26 December 1961 (1961-12-26) * the whole document * ---	1	
A	US 4 382 238 A (MAKIMOTO ET AL.) 3 May 1983 (1983-05-03) * column 5, line 31 - column 6, line 12; figure 7 * ---	1	TECHNICAL FIELDS SEARCHED (Int.Cl.7)
A	EP 0 675 560 A (MURATA MANUFACTURING CO LTD) 4 October 1995 (1995-10-04) * column 5, line 13 - column 6, line 44; figure 1 * ---	1	H01P H03H
A	PATENT ABSTRACTS OF JAPAN vol. 018, no. 255 (E-1548), 16 May 1994 (1994-05-16) -& JP 06 037510 A (MURATA MFG CO LTD), 10 February 1994 (1994-02-10) * abstract; figures 1,2,5-8 * ---	1	
A	US 5 386 203 A (ISHIHARA JINSEI) 31 January 1995 (1995-01-31) * the whole document * --- -/--	1	

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	15 January 2003	Den Otter, A

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EUROPEAN SEARCH REPORT

Application Number
EP 02 02 2889

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
D,A	PATENT ABSTRACTS OF JAPAN vol. 15, no. 494 (E-1145), 13 December 1991 (1991-12-13) & JP 03 216002 A (FUJI ELECTROCHEM CO LTD), 24 September 1991 (1991-09-24) * abstract * -----	1	
			TECHNICAL FIELDS SEARCHED (Int.Cl.7)

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	15 January 2003	Den Otter, A

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15-01-2003

Patent document cited in search report		Publication date	Patent family member(s)			Publication date
EP 641035	A	01-03-1995	DE	69426283	D1	21-12-2000
			DE	69426283	T2	15-03-2001
			EP	0641035	A2	01-03-1995
			EP	0917232	A2	19-05-1999
			EP	0917233	A2	19-05-1999
			EP	0917234	A2	19-05-1999
			EP	0917235	A2	19-05-1999
			JP	7312503	A	28-11-1995
			US	5719539	A	17-02-1998
			US	6304156	B1	16-10-2001
			US	6020799	A	01-02-2000
JP 06085506	A	25-03-1994	JP	3201005	B2	20-08-2001
US 3015099	A	26-12-1961	NONE			
US 4382238	A	03-05-1983	JP	1387946	C	14-07-1987
			JP	56079502	A	30-06-1981
			JP	61050523	B	05-11-1986
EP 675560	A	04-10-1995	JP	7273502	A	20-10-1995
			DE	69513072	D1	09-12-1999
			DE	69513072	T2	14-09-2000
			EP	0675560	A1	04-10-1995
			US	5668511	A	16-09-1997
JP 06037510	A	10-02-1994	NONE			
US 5386203	A	31-01-1995	JP	6188622	A	08-07-1994
JP 03216002	A	24-09-1991	NONE			

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82